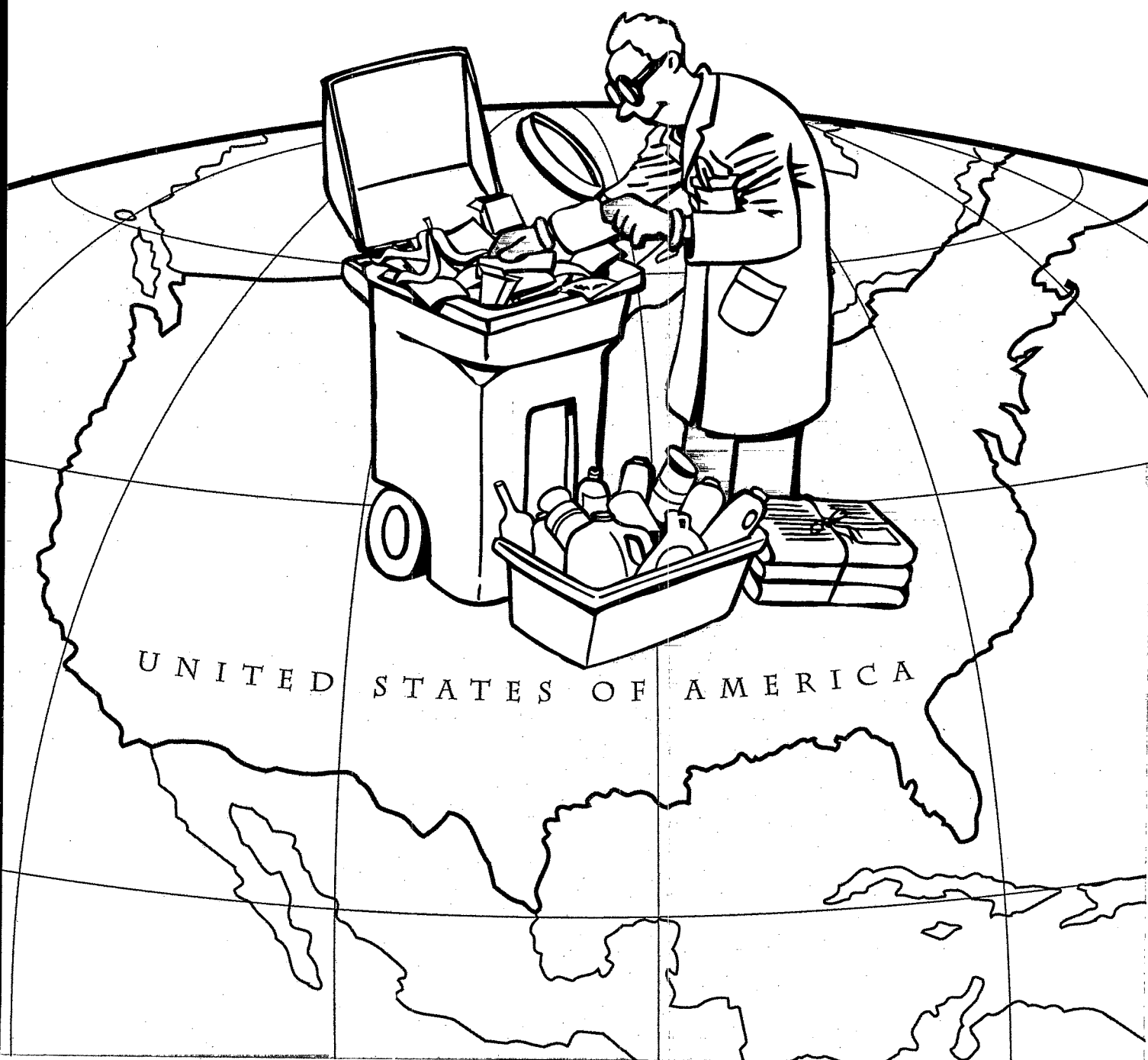




# Characterization of Municipal Solid Waste in the United States: 1994 Update

## Executive Summary





## ERRATA SHEET

### *Characterization of Municipal Solid Waste in the United States: 1994 Update*

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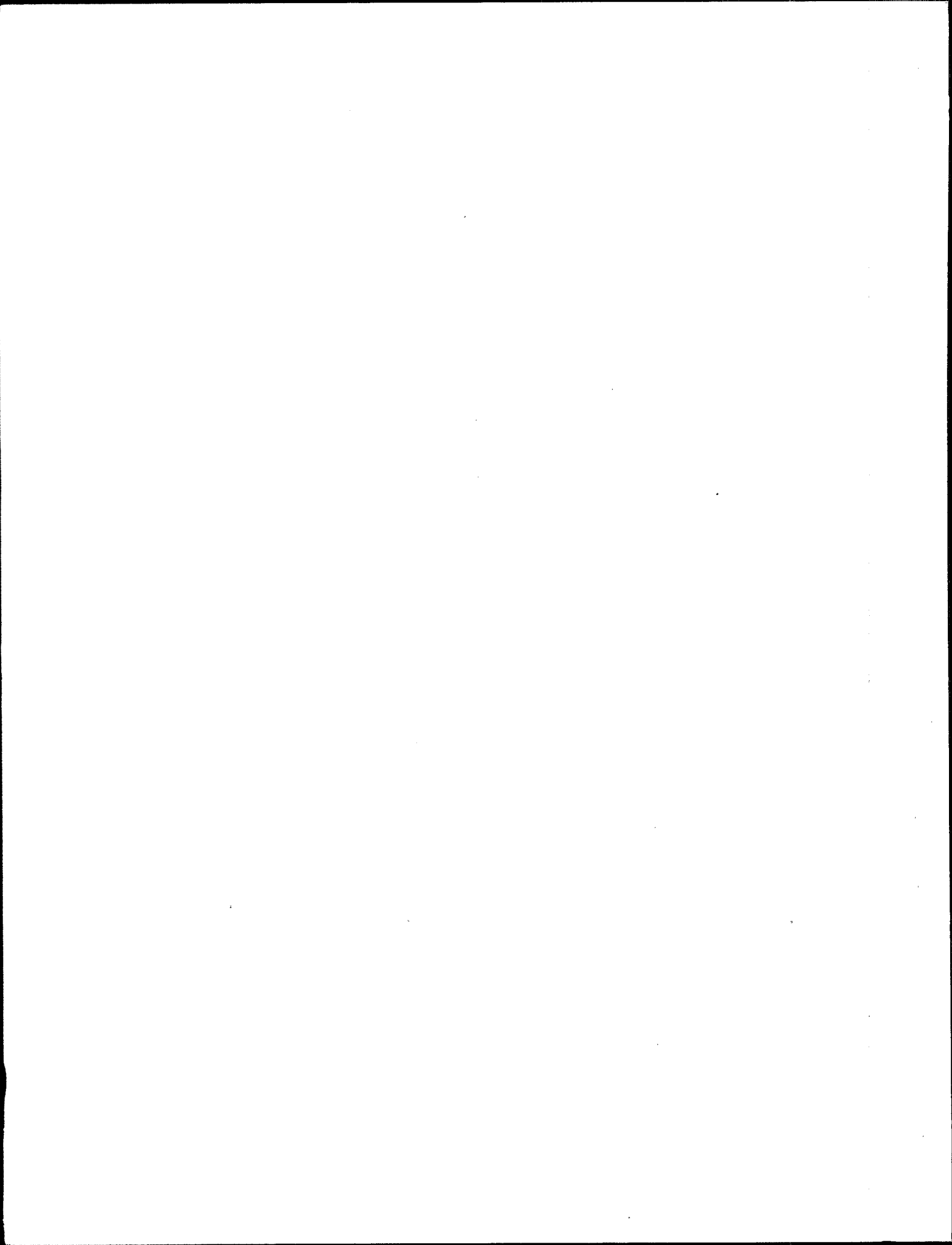
#### Executive Summary

*Page 4, third bullet, change to read:*

Between 1990 and 1993, recovery of materials for recycling and composting increased from 33 million tons to 45 million tons, an increase of 37 percent.



Solid Waste and  
Emergency Response  
(5305)



# CHARACTERIZATION OF MUNICIPAL SOLID WASTE IN THE UNITED STATES: 1994 UPDATE

## Executive Summary

Management of the nation's municipal solid waste (MSW) continues to be a high priority issue for many communities as we near the turn of the century. Increasingly, the concept of integrated solid waste management—source reduction of wastes before they enter the waste stream, recovery of generated wastes for recycling and composting, and environmentally sound disposal through combustion facilities and landfills that meet current standards—is being used by communities as they plan for the future.

There are many regional variations that require each community to examine its own waste management needs. Such factors as local and regional availability of suitable landfill space, proximity of markets for recovered materials, population density, commercial and industrial activity, and climatic and groundwater variations all may motivate each community to make its own plans.

Identifying the components of the waste stream is an important step toward addressing the issues associated with the generation and management of municipal solid wastes. MSW characterizations, which analyze the quantity and composition of the municipal solid waste stream, involve estimating how much MSW is generated, recycled, combusted, and disposed of in landfills. By determining the makeup of the waste stream, waste characterizations also provide valuable data for setting waste management goals, tracking progress toward those goals, and supporting planning at the national, state, and local levels. For example, waste characterizations can be used to highlight opportunities for source reduction and recycling and provide information on any special management issues that should be considered.

Readers should note that this report characterizes the municipal solid waste stream of *the nation as a whole*. Local and regional variations are not addressed, but suggestions for use of the information in this report by local planners are included in Chapter 1.

## FEATURES OF THIS REPORT

This report is the most recent in a series of reports released by the U.S. Environmental Protection Agency (EPA) to characterize MSW in the United States. It characterizes the national waste stream based on data through 1993 and includes:

- Information on MSW generation from 1960 to 1993
- Information on MSW management—recovery for recycling and composting, combustion, and landfilling—from 1960 to 1993
- A discussion of the role of source reduction in MSW management
- Information on the relationship of MSW generation to population and economic activity
- Information characterizing MSW by volume as well as by weight
- Projections for MSW generation to the year 2000
- Projections for MSW combustion through 2000
- Projections (presented in three recovery scenarios) for materials recovery for recycling and composting through 2000.

#### DEFINITIONS

**Municipal solid waste** includes wastes such as durable goods, nondurable goods, containers and packaging, food scraps, yard trimmings, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Examples of waste from these categories include appliances, automobile tires, newspapers, clothing, boxes, disposable tableware, office and classroom paper, wood pallets, and cafeteria wastes. MSW does not include wastes from other sources, such as construction and demolition wastes, automobile bodies, municipal sludges, combustion ash, and industrial process wastes that might also be disposed in municipal waste landfills or incinerators.

**Source reduction** activities reduce the amount or toxicity of wastes before they enter the municipal solid waste management system (see **Generation**). Reuse of products such as refillable glass bottles or refurbished wood pallets is counted as source reduction, not recovery for recycling.

**Generation** refers to the amount (weight, volume, or percentage of the overall waste stream) of materials and products as they enter the waste stream and before materials recovery, composting, or combustion takes place.

**Recovery of materials** includes materials or yard trimmings removed from the waste stream for the purpose of recycling or composting. Recovery for recycling as defined for this report includes purchases of postconsumer recovered materials plus exports of the materials. Recovery of yard trimmings includes those materials received at a composting facility. For some materials, recovery for uses such as highway construction or insulation is counted as recovery along with materials used in remanufacturing processes.

**Combustion** includes combustion of mixed MSW, fuel prepared from MSW, or a separated component of MSW (such as rubber tires), with or without energy recovery.

**Discards** include the municipal solid waste remaining after recovery for recycling and composting. These discards are usually combusted or disposed of in landfills, although some MSW is littered, stored, or disposed on site, particularly in rural areas.

By presenting three possible scenarios for recovery in the year 2000, this report illustrates how various recovery rates (25, 30, and 35 percent) could be achieved. States and local communities can set their own goals and recovery scenarios depending upon their local situations.

## **METHODOLOGY**

There are two primary methods for conducting a waste characterization study. The first is a source-specific approach in which the individual components of the waste stream are sampled, sorted, and weighed. Although this method is useful for defining a local waste stream, extrapolating from a limited number of studies can produce a skewed or misleading picture if used for a nationwide characterization of waste. Any errors in the sample or atypical circumstances encountered during sampling would be greatly magnified when expanded to represent the nation's entire waste stream.

The second method, used in this report to estimate the waste stream on a nationwide basis, is called the "material flows methodology." EPA's Office of Solid Waste and its predecessors in the Public Health Service sponsored work in the 1960s and early 1970s to develop the material flows methodology. This methodology is based on production data (by weight) for the materials and products in the waste stream, with adjustments for imports, exports, and product lifetimes.

## **REPORT HIGHLIGHTS**

This report demonstrates that the generation of municipal solid waste continues to increase steadily, both in overall tonnage and in pounds per capita. There is some evidence that source reduction measures, particularly efforts to keep yard trimmings out of the waste management system, are beginning to have an effect. Increasing recovery of materials in MSW for recycling and composting is leading to a decline in the percentage of MSW being sent to disposal facilities. Major findings include the following:

- In 1993, 207 million tons, or 4.4 pounds per person per day, of MSW were generated. After materials recovery for recycling and composting, discards were 3.4 pounds per person per day. Virtually all of these discards were combusted or sent to landfills.
- For the first time, EPA projects that the per capita generation rate will decrease by the year 2000 to 4.3 pounds per person per day. These projections are based in part on source reduction efforts, especially actions to divert yard trimmings from the solid waste management system through backyard composting and leaving grass clippings on lawns. States that include more than half of the U.S. population already have regulations leading to these actions. Other source

reduction activities, e.g., reduced packaging, are also contributing to this decrease.

- Even with significant source reduction efforts, generation of MSW is projected to increase to 218 million tons in 2000. However, discards to combustion facilities or landfills are projected to decline from 162 million tons in 1993 to 152 million tons in 2000 assuming a 30 percent recovery rate for recycling and composting is achieved.
- Recovery of materials for recycling and composting was estimated to be 22 percent of MSW generated in 1993, up from 17 percent in 1990, continuing the impressive growth of recent years. Combustion facilities managed 16 percent of total generation, and the remaining 62 percent of the municipal solid waste stream was sent to landfills or otherwise disposed.
- Between 1990 and 1993, recovery of materials for recycling and composting increased from 38 million tons to 45 million tons, an increase of 18 percent. Recovery of paper and paperboard accounted for over half of this increased tonnage. Yard trimmings for composting contributed the next largest increase in tonnage recovered.
- The percentage of MSW discards continues to decline due to increased levels of recovery for recycling and composting. In 1985, 83 percent of MSW was landfilled compared to 62 percent landfilled in 1993. Even with this reduction, landfilling continues to be the single most predominant waste management method into the year 2000.

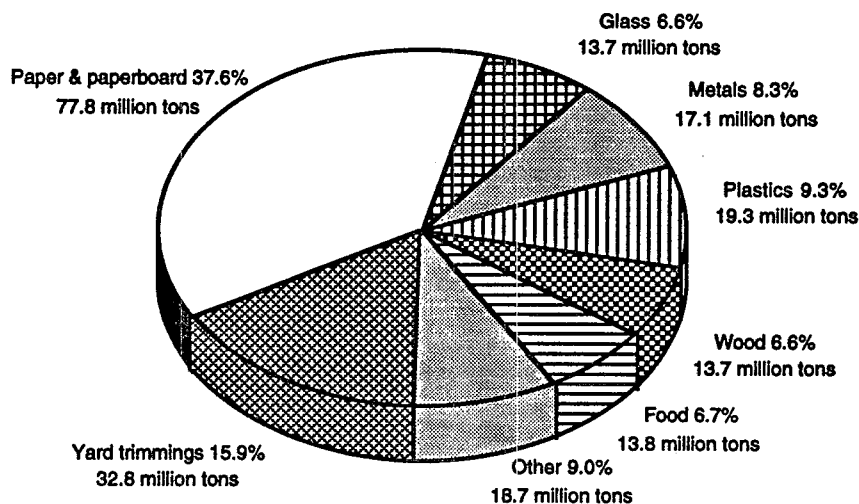
## **MUNICIPAL SOLID WASTE IN 1993**

### **Materials in MSW**

In 1993, generation of municipal solid waste totaled 207 million tons. A breakdown by weight of the *materials* generated in MSW in 1993 is shown in Figure ES-1 and Table ES-1. Paper and paperboard products are the largest component of municipal solid waste by weight (38 percent of generation) and yard trimmings are the second largest component (16 percent of generation). Five of the remaining materials in MSW—glass, metals, plastics, wood and food wastes—range between 6 and 9 percent each by weight of total MSW generated. Other materials in MSW include rubber and leather, textiles, and small amounts of miscellaneous wastes, which each made up approximately 3 percent of MSW in 1993.



**Figure ES-1. Materials generated in MSW by weight, 1993**  
(Total weight = 206.9 million tons)



**Table ES-1**

**GENERATION AND RECOVERY OF MATERIALS IN MSW, 1993**  
(In millions of tons and percent of generation of each material)

	Weight Generated	Weight Recovered	Percent of Generation
Paper and paperboard	77.8	26.5	34.0%
Glass	13.7	3.0	22.0%
Metals			
Ferrous metals	12.9	3.4	26.1%
Aluminum	3.0	1.1	35.4%
Other nonferrous metals	1.2	0.8	62.9%
<i>Total metals</i>	17.1	5.2	30.4%
Plastics	19.3	0.7	3.5%
Rubber and Leather	6.2	0.4	5.9%
Textiles	6.1	0.7	11.7%
Wood	13.7	1.3	9.6%
Other materials	3.3	0.7	22.1%
<i>Total Materials in Products</i>	157.3	38.5	24.5%
Other Wastes			
Food Wastes	13.8	Neg.	Neg.
Yard Trimmings	32.8	6.5	19.8%
Miscellaneous Inorganic Wastes	3.1	Neg.	Neg.
<i>Total Other Wastes</i>	49.7	6.5	13.1%
<b>TOTAL MUNICIPAL SOLID WASTE</b>	<b>206.9</b>	<b>45.0</b>	<b>21.7%</b>

Includes wastes from residential, commercial, and institutional sources.

Neg. = Less than 50,000 tons or 0.05 percent.

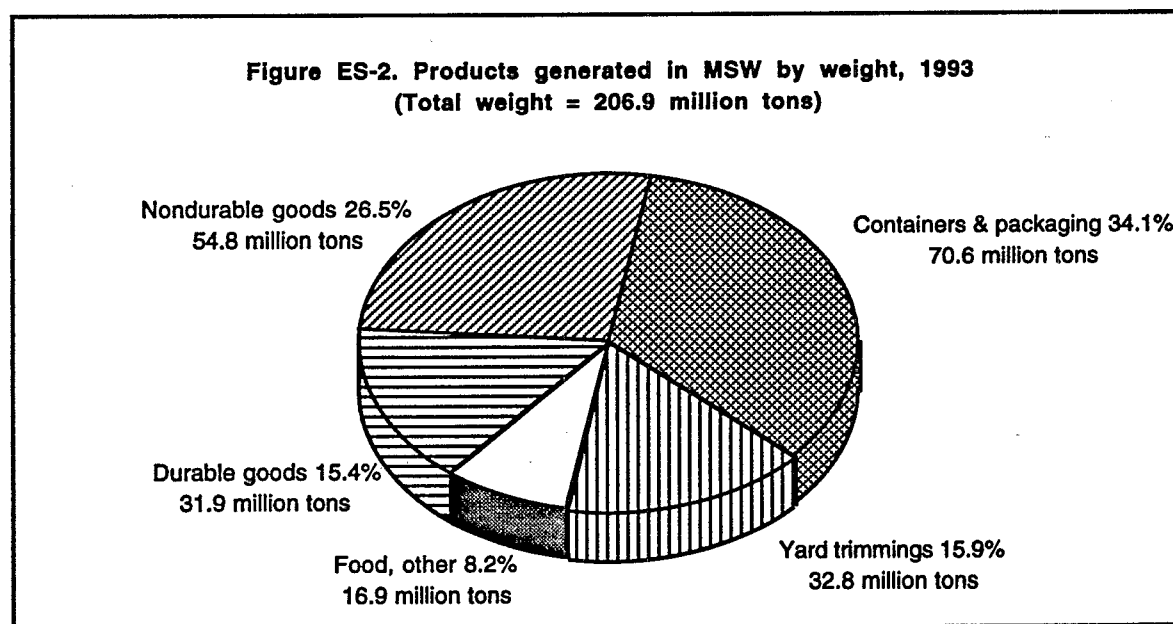
Numbers in this table have been rounded to the first decimal place.

Most of the materials in MSW have some level of recovery for recycling or composting. This is illustrated for 1993 in Table ES-1. Since each material category (except for food wastes and yard trimmings) is made up of many different products, some of which may not be recovered at all, the overall recovery rate for any particular material will be lower than recovery rates for some products within the materials category.

The highest recovery rate shown in Table ES-1 is that for nonferrous metals other than aluminum (63 percent of generation). This is because the lead in lead-acid batteries is recovered at very high rates. Aluminum is recovered at approximately 35 percent of generation overall, even though aluminum cans are recovered at rates above 60 percent. Likewise, the overall recovery rate for paper and paperboard is 34 percent, even though corrugated containers are recovered at rates above 50 percent.

### Products in MSW

The many products in MSW are grouped into three main categories: durable goods (for example, appliances), nondurable goods (for example, newspapers), and containers and packaging (Figure ES-2). The materials in MSW are generally made up of products from each category. There are exceptions, however. The durable goods category contains no paper and paperboard. The nondurable goods category includes only small amounts of metals and essentially no glass or wood. The containers and packaging category includes only very small amounts of rubber, leather, and textiles.



Generation and recovery of the product categories in MSW, broken down by materials within each category, are shown in Table ES-2. Overall, the materials in durable goods were recovered at a rate of approximately 13 percent in 1993. The non-ferrous metals were recovered at a rate of approximately 63 percent because of the high rate of recovery of lead-acid batteries. (The recovery of these batteries also accounts for the high rate of recovery of "other materials," which are the non-lead components of the batteries.) Considerable amounts of ferrous metals are recovered from appliances in the durables category, and some rubber is recovered from tires.

Overall recovery in the nondurable goods category was estimated to be 21 percent in 1993. In this category, large amounts of newspapers, office papers, and some other paper products are recovered.

Recovery from the containers and packaging category is the highest of these categories—33 percent of generation. Aluminum was recovered at over 53 percent in 1993 (mostly aluminum beverage cans), while steel (mostly cans) was recovered at over 46 percent. Paper and paperboard recovery was estimated at 44 percent overall in 1993, with corrugated containers accounting for most of that tonnage. Glass containers were estimated to have been recovered at 25 percent overall, while wood packaging (mostly pallets) was estimated to have been recovered at 14 percent of generation. Plastic containers and packaging were estimated to have been recovered at an overall rate of 6 percent in 1993, with most of the recovered plastics being soft drink bottles and milk and water bottles.

### **Management of MSW**

The breakdown of how much waste went to recycling and composting, combustion, and landfills in 1993 is shown in Figure ES-3. Recovery of materials for recycling and composting was estimated to have been 45 million tons, or 22 percent of generation, in 1993. Combustion of MSW (nearly all with energy recovery) was estimated to have been 33 million tons, or 16 percent of generation, in 1993. The remainder, 129 million tons of MSW (62 percent of generation), was assumed to have been landfilled (although small amounts may have been littered or self-disposed, e.g., on farms).

Recovery for recycling remained at relatively low levels—9 to 10 percent of MSW generation—well into the decade of the 1980s. In the late 1980s, people nationwide realized that new approaches to solid waste management were needed, and recovery for recycling and composting began to increase. Recovery rates have increased from 13 percent in 1988 to 17 percent in 1990 to 22 percent in 1993 (Figure ES-4).

**Table ES-2**  
**GENERATION AND RECOVERY OF PRODUCTS IN MSW**  
**BY MATERIAL, 1993**  
(In millions of tons and percent of generation of each product)

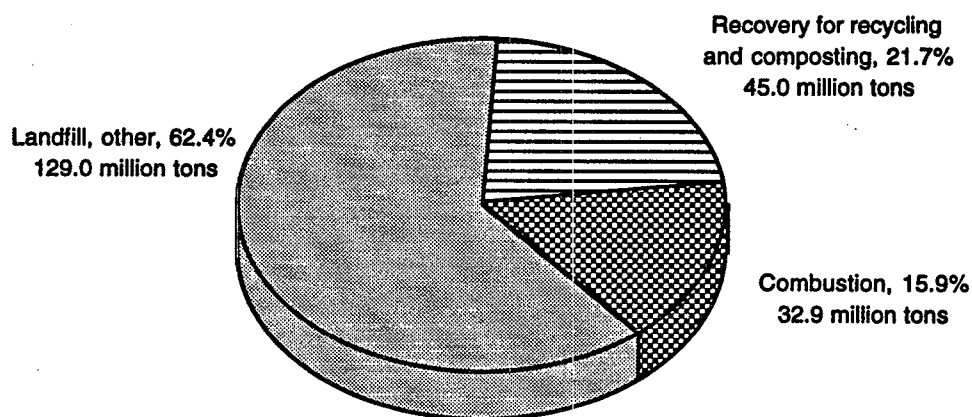
	Weight Generated	Weight Recovered	Percent of Generation
<b>Durable goods</b>			
Ferrous metals	10.0	2.0	20.0%
Aluminum	0.8	Neg.	Neg.
Other non-ferrous metals	1.2	0.8	62.9%
<i>Total metals</i>	12.0	2.8	23.1%
Glass	1.4	Neg.	Neg.
Plastics	6.3	0.2	2.4%
Rubber and leather	5.2	0.4	7.1%
Wood	4.2	Neg.	Neg.
Textiles	1.8	Neg.	1.7%
Other materials	1.0	0.7	76.0%
<i>Total durable goods</i>	31.9	4.1	12.7%
<b>Nondurable goods</b>			
Paper and paperboard	42.4	10.8	25.4%
Plastics	4.6	Neg.	<1%
Rubber and leather	1.0	Neg.	Neg.
Textiles	4.3	0.7	16.2%
Other materials	2.5	Neg.	Neg.
<i>Total nondurable goods</i>	54.8	11.5	21.0%
<b>Containers and packaging</b>			
Steel	3.0	1.4	46.3%
Aluminum	2.0	1.1	53.3%
<i>Total metals</i>	5.0	2.4	49.1%
Glass	12.2	3.0	24.6%
Paper and paperboard	35.4	15.7	44.2%
Plastics	8.4	0.5	6.1%
Wood	9.5	1.3	13.9%
Other materials	0.1	Neg.	Neg.
<i>Total containers and packaging</i>	70.6	22.9	32.5%
<b>Other wastes</b>			
Food wastes	13.8	Neg.	Neg.
Yard trimmings	32.8	6.5	19.8%
Miscellaneous inorganic wastes	3.1	Neg.	Neg.
<i>Total other wastes</i>	49.7	6.5	13.1%
<b>TOTAL MUNICIPAL SOLID WASTE</b>	<b>206.9</b>	<b>45.0</b>	<b>21.7%</b>

Includes wastes from residential, commercial, and institutional sources.

Neg. = less than 50,000 tons or 0.05 percent.

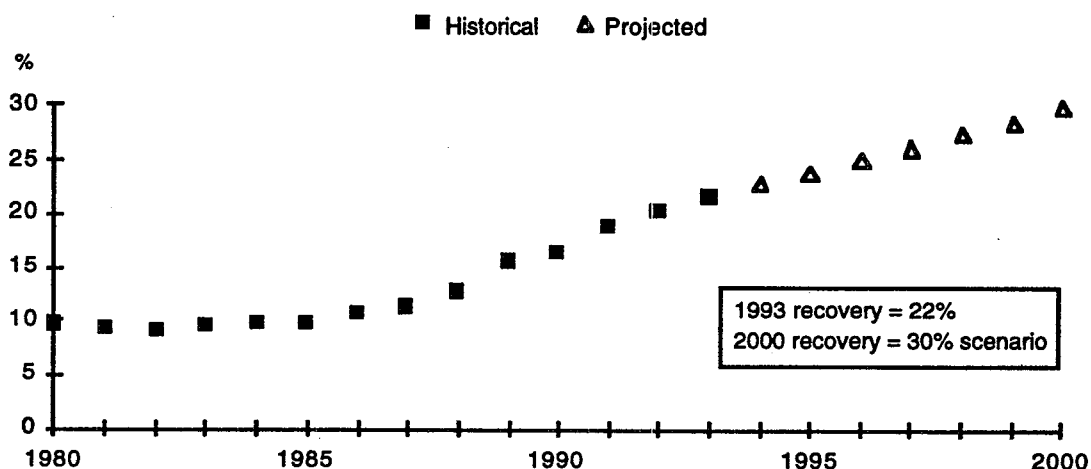
Numbers in this table have been rounded to the first decimal place.

**Figure ES-3. Management of MSW in U.S., 1993**  
(Total weight = 206.9 million tons)



For this report, EPA looked at a range of recovery scenarios from 25 percent to 35 percent nationwide for the year 2000. A mid-range projected scenario of 30 percent in the year 2000 was used to illustrate the effects of recovery on future municipal solid waste management. To achieve this level of recovery, it was assumed that local, state, and federal agencies will continue to emphasize recycling and composting as a priority; that industries will continue

**Figure ES-4. Recovery for recycling and composting**  
(in percent of total MSW generation)



to make the necessary investments in recovery and utilization of materials; that state and local governments will continue to expand programs designed to keep yard trimmings out of landfills; and that most U.S. citizens will have access to some sort of recovery program by the year 2000.

### **Source Reduction**

Source reduction activities include the design, manufacture, purchase, or use of materials (such as products and packaging) to reduce the amount or toxicity of trash before it reaches the point of generation and enters the municipal solid waste management system. Source reduction activities include:

- Designing products or packages so as to reduce the quantity of materials or the toxicity of the materials used
- Reducing amounts of products or packages used through modification of current practices
- Reusing products or packages already manufactured
- Lengthening the life of products to postpone disposal
- Managing non-product organic wastes (food wastes, yard trimmings) through on-site composting or other alternatives to disposal.

While most source reduction activities were not quantified in this report, calculations were made showing that yard trimmings generation could be reduced 30 percent or more by the year 2000 if current and planned state and local programs to reduce disposal of yard trimmings are implemented.

### **MSW Volume Estimates**

Although solid waste is usually characterized by weight, information about volume is important for such issues as determining how quickly landfill capacity is being filled and identifying the rates at which the volumes of various materials in the waste stream are changing.

Volume estimates of solid waste are, however, far more difficult to make than weight estimates. A pound of paper is a pound of paper whether it is in flat sheets, crumpled into a wad, or compacted into a bale, but the volume occupied in each case will be very different. The estimates presented here represent the relative volume of materials as they would typically be found if compacted individually in a landfill (a significant amount of compaction occurs in a landfill). These estimates are based largely on empirical data that are then used to estimate density factors (pounds per cubic yard) for components of solid waste

under simulated landfill conditions, with corroboration from actual landfill studies. It should be noted, however, that individual component density measurements serve only to compare component volume requirements, one to another. The component measurements should *not* be used to estimate landfill densities of mixed municipal solid waste.

Figure ES-5 shows the materials in MSW by volume as a percentage of total MSW discards (after recovery) in 1993. The paper and paperboard category ranks first in volume of MSW discarded (30 percent). Plastics rank second in volume, at 24 percent of the total, and yard trimmings are third, at 8 percent. Paper and plastics combined accounted for over one-half of the volume of MSW discarded in 1993.

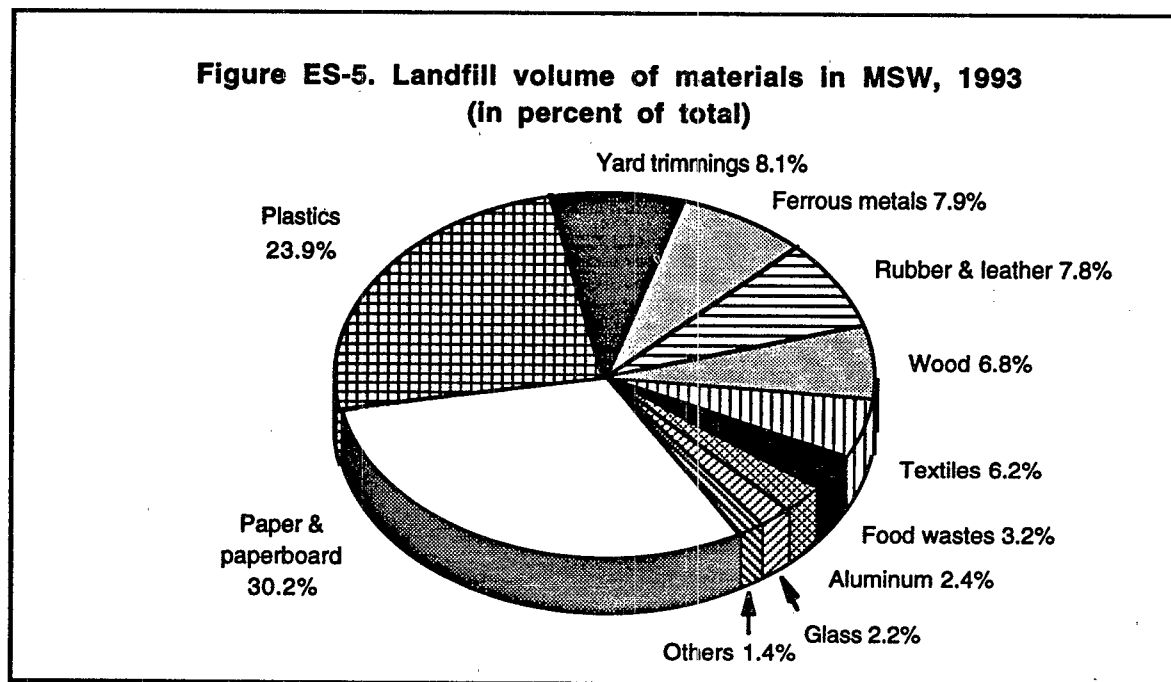
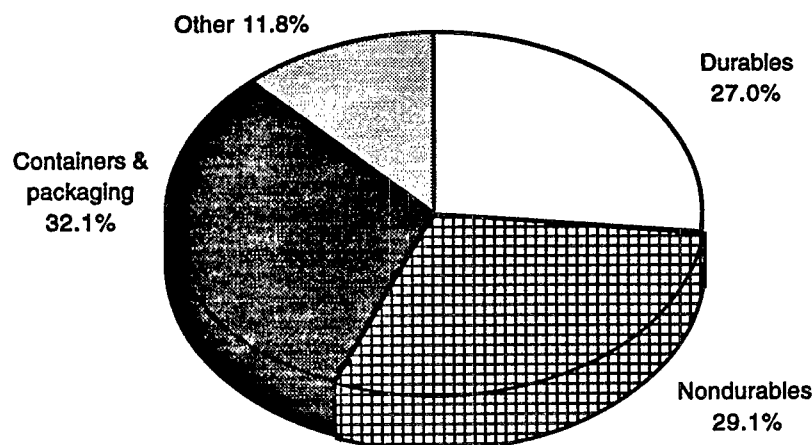


Figure ES-6 shows the product categories that made up MSW by volume of total discards in 1993. Containers and packaging were 32 percent of discards after recovery for recycling and composting, while nondurable goods were 29 percent of discards. Durable goods were an estimated 27 percent of MSW discards volume, while other materials (mostly yard trimmings and food wastes) were approximately 12 percent of discards by volume.

**Figure ES-6. Landfill volume of products in MSW, 1993  
(in percent of total)**



## **ADDITIONAL PERSPECTIVES ON MSW**

### **Per Capita Generation of MSW**

Generation of MSW by individuals is an important parameter used by solid waste management planners. During the period 1960 to 1993, per capita generation of MSW increased steadily from 2.7 pounds per person per day to 4.4 pounds per person per day. During the period 1993 to 2000, per capita generation of products (including packaging) is projected to continue to increase if present trends continue. The per capita generation of yard trimmings is, however, projected to decline if current source reduction activities at the state and local levels continue. Overall, this could mean a decline in per capita generation from 4.4 pounds per person per day in 1993 to 4.3 pounds per person per day in 2000.

### **Residential and Commercial Sources of MSW**

The sources of MSW as characterized in this report include both residential and commercial locations (commercial locations include institutions such as schools and some industrial sites where packaging is generated). The source where the MSW is generated is highly relevant to management techniques, including collection for disposal and collection for purposes of recycling or composting.

For this report, estimates of residential and commercial generation of MSW were made. Residential wastes (including wastes from multi-family



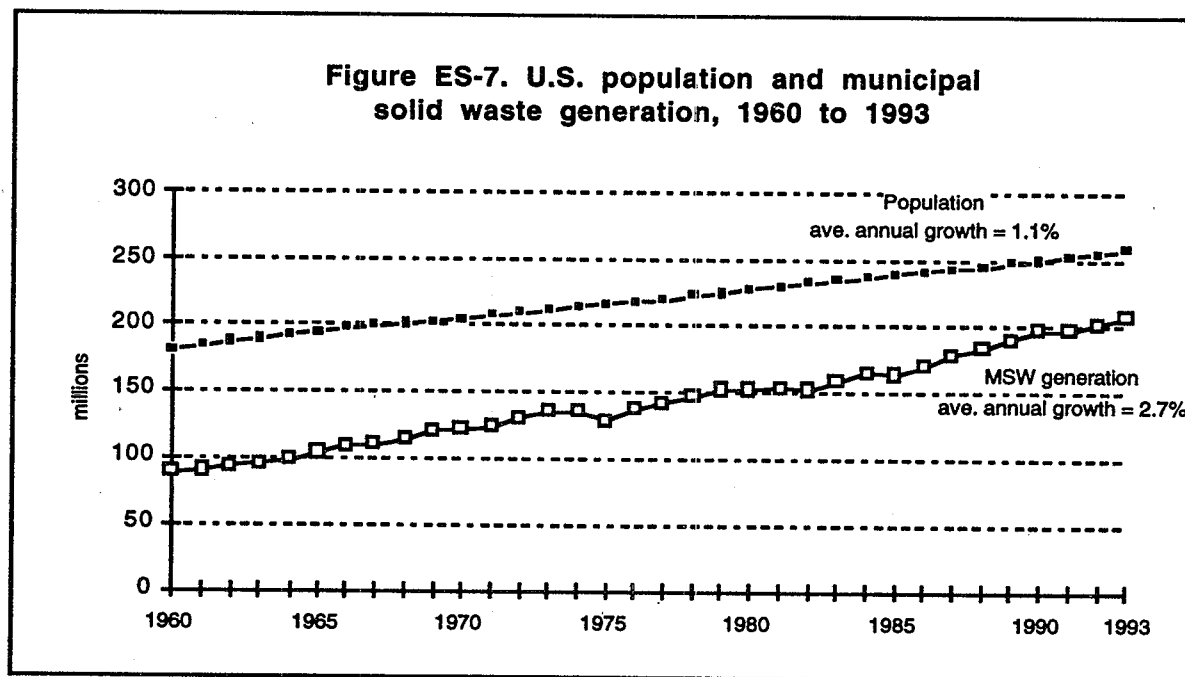
dwellings) are estimated to be 55 to 65 percent of total generation, with commercial wastes ranging between 35 and 45 percent of generation. Local and regional factors such as climate and level of commercial activity contribute to the variations.

### Factors Affecting MSW Generation

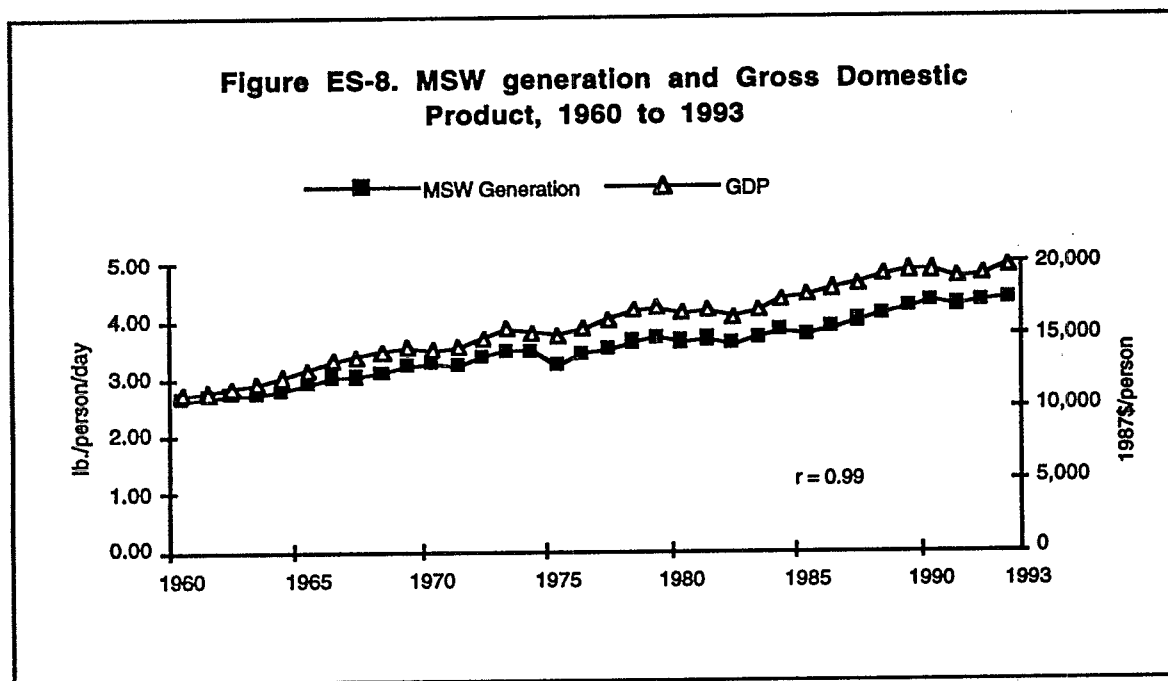
For the first time in this series of reports, the correlation of historical MSW generation with factors such as population and economic activity was analyzed. Increasing population clearly contributes to increasing generation of MSW. In statistical language, the correlation coefficient ( $r$ ) between MSW generation and population from 1960 to 1993 is 0.99, a high degree of correlation.

Population is not the only factor leading to increased MSW generation; historical trends show that MSW generation has been increasing more rapidly than population (Figure ES-7). While average annual population growth over the 33-year period was 1.1 percent, average annual growth of MSW generation was 2.7 percent. In other words, per capita generation of MSW increased over the historical period.

Many reasons have been suggested for the growth in per capita MSW generation, such as changes in lifestyles, more two-income wage earners in households, smaller households, and changes in the workplace (especially in offices). It seems clear that many of these reasons are related to changes in the level of economic activity, which has been generally upward except for



occasional recessions. A plot of per capita MSW generation and economic activity as measured by Gross Domestic Product (GDP) (in 1987 dollars per capita) is shown in Figure ES-8. During the 33-year period, MSW per capita generation increased 65 percent, while GDP on a per capita basis increased 82 percent. The correlation coefficient ( $r$ ) between per capita MSW generation and per capita GDP is 0.99, a strong positive correlation.



On the basis of this preliminary analysis, it appears that population growth accounts for a portion of the increase in MSW generation, but that economic activity (and perhaps other factors such as household size) contributes to the increase over and above population growth.

#### TRENDS IN MSW GENERATION, RECOVERY, AND DISCARDS

*Generation* of municipal solid waste grew steadily between 1960 and 1993, from 88 million to 207 million tons per year. Per capita generation of MSW increased from 2.7 pounds per person per day in 1960 to 4.4 pounds per person per day in 1993. Projected per capita MSW generation in the year 2000 is 4.3 pounds per person per day (218 million tons). The projected decline in per capita generation rates is based in large part on a projected decrease in the tonnage of yard trimmings entering the municipal solid waste management system. Actually achieving the projected decline hinges on continued emphasis on source reduction of yard trimmings in particular, but also on other products in MSW.

*Recovery* for recycling and composting has increased from approximately 7 percent of MSW generated in 1960 to 22 percent by 1993, with much of the growth happening over the past five or six years. Projected scenarios for recovery are between 25 and 35 percent in 2000. To achieve these recovery rates, some products will have to be recovered at rates of 50 percent or more, and there will have to be substantial composting of yard trimmings.

*Combustors* handled an estimated 30 percent of MSW generated in 1960, mostly through incinerators with no energy recovery and no air pollution controls. In the 1960s and 1970s, combustion dropped steadily as the old incinerators were closed, reaching a low of less than 10 percent of MSW generated by 1980, then increasing to approximately 16 percent of MSW in 1990. Between 1990 and 1993, combustion remained around 16 percent of MSW generation. All major new facilities have energy recovery and are designed to meet air pollution standards.

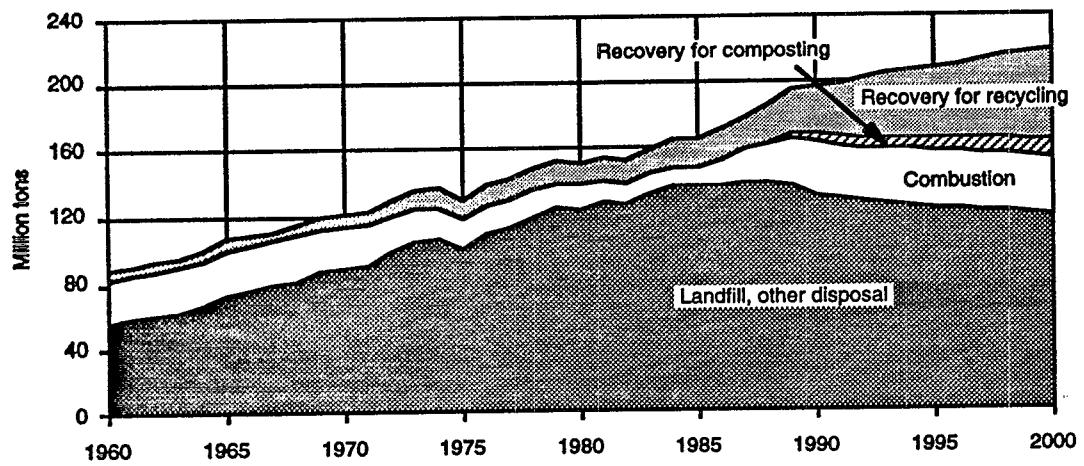
The report projects that tonnage of MSW combusted will increase only slightly by the year 2000—to 34 million tons, or less than 16 percent of generation. Estimates of combustion projections are based on an assumption that the facilities will operate at 85 percent of capacity.

*Landfill* use fluctuates with changes in the use of alternative solid waste management methods. For example, when the use of combustion for MSW management declined and recovery rates were low, the MSW percentage sent to landfills increased (Figure ES-9). Alternatively, when recovery and combustion of MSW increased, the percentage of MSW discarded to landfills declined. In 1960, approximately 62 percent of MSW was sent to landfills. This increased to 81 percent in 1980, then decreased to an estimated 62 percent in 1993 (the same percentage but much more tonnage than in 1960) due to changing trends in municipal solid waste management.

Recovery for recycling and composting at the 30 percent scenario in 2000 combined with projected source reduction efforts would reduce total national discards of MSW after recovery to 152 million tons compared to the 1993 level of 162 million tons. Adding projected combustion levels to recovery for recycling and composting would lower landfill tonnage to 118 million tons in 2000 compared to 129 million tons in 1993.

As we approach the twenty-first century, integrated waste management with a focus on source reduction, recycling, and composting is clearly the solution to our growing waste management needs. Through source reduction, recycling, and composting, we can reduce generation and increase recovery, and, in turn, reduce the quantities of waste that must be managed by combustors and landfills.

Figure ES-9. Municipal solid waste management, 1960 to 2000







United States  
Environmental Protection Agency  
(5305)  
Washington, DC 20460

Official Business  
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